PATENT SPECIFICATION

DRAWINGS ATTACHED

1,090,745

1,090,745

Date of Application and filing Complete Specification: March 5, 1965.
No. 9492/65
Application made in Germany (No. F42243viiic/21g) on March 7, 1964.
Application made in Germany (No. F44512viiic/21g) on November 24, 1964.
Complete Specification Published: November 15, 1967.

Index at Acceptance:—**H1** D (8G, 9G, 9L, 9Y, 12A, 12B5, 12B47Y, 38); **G1** A (202, 24Y, 241, 269, 31Y, 316, 35Y, 351, 369, 372, 382, 578, 579, 752, 79Y, 791, 797, 798).

Int. Cl.:—H 01 j 39/30.

COMPLETE SPECIFICATION

The Inventors of this invention in the sense of being the divisers thereof within the meaning of Section 16 of the Patents Act, 1949, are:— Lutz-Axel Wegner, Wuppertal-Elberfeld, Germany, Kaiser-Wilhelm-Allee 42, Hans Schurfeld, Wuppertal-Elberfeld, Germany, Borberg 25. Both of German nationality.

Flow Counter for Measurement of Radioactive materials

We, FARBENFABRIKEN BAYER AKTIENGESELLSCHAFT, of Leverkusen, Germany, a body corporate organised under the laws of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to a flow counter tube without a windowfoil for determining radioactive materials, consisting of a counter tube chamber which contains a counting wire at a positive voltage with respect to the wall of the chamber and which is covered by a plate which has an aperture for admitting radiation, which aperture is not covered by a foil.

Known counters of this kind (e.g. methane proportional counters) are used for determining the local distribution of activity in thin layer or paper chromatograms in cases where the emitter of radiation is of such low energy, e.g. in the case of ^3H, that a covering foil would weaken the particles to be counted too much. Since in contrast to the usual counters there is no covering foil in the arrangements without a window foil, the counter chamber is not separated electrically from the radioactive source. As a result of the gas multiplication in the counter, a large number of positive ions per registered β-particle are produced inside the counter, some of which ions escape to the outside through the aperture in the cover plate of the counter chamber. These ions reach the radioactive source deposited on the source mounting material, because the radioactive source, the activity of which is to be measured, is usually arranged in the immediate vicinity of the aperture of the cover plate; this source may be either "conductive" or "non-conductive". In the case of conductive sources this stream of ions is conducted to the cathode without generating a potential on the surface of the source with respect to the counter tube cathode, if the conductive source mounting material is connected with the cathode of the counter. In the case of non-conductive sources the surface of the source becomes electrostatically charged. Hereinafter, a non-conductive source is understood to mean one in which the ions leaving the inside of the counter produce on the surface of the radioactive source a positive potential difference of Δ 1 V with respect to the counter cathode.

It can further be shown that in a process using a counter without a covering foil, the field inside the counter chamber extends through the aperture and conveys secondarily produced carriers of negative charge and of low energy, formed by the primary β-radiation, into the interior of the counter, where they are counted. Thus if conductive sources are used, rates of counting are obtained which are independent of the distance within a certain range, reproducible and greater than would be expected on the basis of the geometry of the arrangement

if the spread of the β-particles were rectilinear.

In practice one cannot avoid working with non-counducting sources. For example, in thin layer chromatography the radioactive sample is contained in a layer of silica gel of 0.2 to 1 mm. which in turn is disposed on a glass plate of about 4 mm. in thickness. It is well known that when measuring with counters without a window foil, the results obtained in measuring a radioactive sample situated in a non-conductive source are not strictly reproducible because the counter and the source are no longer electrically separated from each other. The surface charges occurring on these sources may, depending e.g. on the geometry of the counter, the rate of counting and the conditions of insulation, lead to potential difference of the order of 10 to 50 V with respect to the counter cathode. The secondarily produced carriers of negative charge, which are produced by the β-particles outside the counter tube, are partly drawn back on to the surface of the source by this positive surface charge and therefore do not reach the interior of the counter tube. Positive surface charges originating in this or some other way hence lead to a reduction in the rate of counting. This is to be regarded as a particular disadvantage of the known counter tubes without window foils because this reduction is not reproducible in practice owing to the fact that the electrostatic charge phenomena causing it are not constant in time and place.

This disadvantage is obviated if according to the invention an additional electric field is produced in the immediate vicinity of the radiation inlet aperture by using an electric diaphragm system such that the aperture lies in the region of this additional field. The result obtained is that the above-mentioned secondarily produced charge carriers of low energy, which are the cause for the non-reproducible counting results and which arise outside the volume of the counter tube are withdrawn as they pass the aperture and hence do not contribute to the counting result. A further result is that the plateau inclinations are considerably smaller than in the comparable counters without window foils in which no additional field is provided.

Moreover, for a given rate of flow of methane, the rate of counting is more independent of disturbances in the air in the vicinity of the counter.

The electric diaphragm system is formed for example by two conductive plates which are arranged above one another and have a common slot-shaped aperture and which are separated by an electrically insulating intermediate layer with the same slot-shaped aperture. The additional field is produced by applying a voltage to the two plates. In a diaphragm system of this kind in which the vector of field strength of the additional field is situated in the aperture parallel or antiparallel to the vector of the counter tube field, the counter tube field could be additionally compensated in the case of the antiparallel arrangement, so that it is possible to influence the stream of ions which leave the counter tube and are the cause of the charge. This can be achieved if the diaphragm system is so arranged that the additional field has a component which is perpendicular to the plane of the cover plate in the aperture of the cover plate.

The electrical diaphragm system may also consist of a slotted electrically conductive plate and an electrically insulating layer, also provided with a slotted aperture, arranged on this plate, and two intermeshing tooth wire combs insulated from each other arranged on this layer and covering the slotted aperture like a grid. The additional field is produced by applying a voltage to the wire combs.

For measuring conductive radioactive sources on a conductive source-mounting material, the additional field can be produced between this conductive, electrically insulated mounting material and the conductive cover plate of the counter tube, which plate is provided with an aperture for admitting radiation. The voltage applied to the mounting material is in this case positive with respect to the plate which is at the potential of the counter cathode. This principle of introducing the sample to be measured between the electrodes which produce the additional field can be used in some cases also for measuring non-conductive sources. It has been found that the effect of withdrawing the negative charge carriers outside the counter can also be produced in the case of comparatively well insulating layers of radioactive material and source-mounting materials such as radioactive layers of silica gel on glass. In this case the additional field again is produced between a conductive, electrically insulated support of the mounting material and the conductive cover plate which is at the potential of the cathode and which is provided with an aperture for admitting radiation.

The non-conductive mounting material is placed on the said conductive support in such a way as to produce the best possible galvanic contact between the mounting material and the support.

When measuring a mixture of β-emitting isotopes of low and different maximum energies e.g. ^{3}H and ^{14}C in a sample of advisably a good conductivity the windowless flow counter with additional field according to the invention provides the possibility of determining the count rate of each com-

ponent by running two measurements with two different intensities of the additional field. This can be explained by the fact that field. This can be explained by the fact that—depending upon the intensity of the additional field—a smaller or greater fraction of the secondarily produced carriers of negative charge is withdrawn before reaching the chamber of the flow counter, thus resulting in a variation of sensitivity and furthermore, that this variation of sensitivity is different for β-emitters of differing maximum β energy. For instance by suitable choice of the geometry of the electrical diaphragm system a counting of the extremely soft β-particles of ^3H can be completely supressed, when the field is switched on; because of the small maximum range of ^3H-particles all those diaphragm systems are suitable which prevent the β-particles from entering the chamber and only admit the secondarily produced charge carriers of them if the field is switched off. When the field is switched on, only β-particles of higher energy than those of ^3H, e.g. those due to ^{14}C., can be counted, whilst both types of particles are counted if the additional field is switched off.

If ^3H and e.g. ^{14}C are present simultaneously in a mixture, they can also be measured at nearly the same time by varying (or in the simplest case by switching on and off) the field periodically. The additional field being switched on and off represents a special case of an additional field which contains in addition to a direct voltage component a periodically alternating voltage component.

On the other hand the principle of introducing the sample to be measured between the electrodes which produce the additional field can be used in some cases of measuring non-conductive sources not in the way described above but in such a way that an increase in the rate of counting is obtained if, according to the invention, a negative potential is applied to the conductive, electrically insolated support of the mounting material with respect to the conductive cover plate. This is only possible if a surface potential of about 10 v or more is produced on the surface of the non-conductive source under normal conditions i.e. when no additional field is used.

Although the surface charge of the source due to the ions of the counter tube is then increased by applying this negative potential, if a sufficiently high negative potential is supplied to the conductive support then the resulting potential on the surface of the source falls with respect to the cathode, passes through O V and may in some cases even assume negative values. Such a reduction of the potential to O V is accompanied by an increase in the counting efficiency.

An embodiment of apparatus according to the invention will now be described, by way of illustration only, with reference to the accompanying drawings, in which:—

Fig. 1 is a cross-section through a flow counter without a window foil provided with a simple electrical diaphragm system;

Fig. 2 is the top plan view of another electrical diaphragm system for the counter illustrated in Fig. 1;

Fig. 3 is a cross-section through the electrical diaphragm system of Fig. 2;

Fig. 4 is a top plan view of yet another kind of electrical diaphragm system and

Fig. 5 is a cross-section through the system illustrated in Fig. 4;

Fig. 6 gives the experimental results of measuring a sample with the arrangement according to Fig. 1, using a non-conductive source which is mounted on a non-conductive mounting material which is a glass plate. The rate of counting was determined for five different radioactive samples depending upon the voltage U_s applied at 13 with respect to 12.

In Fig. 1 the reference numeral 1 denotes the metal body of the flow counter, also termed the counter cathode, 2 the chamber of the flow counter, 3 the flow counter wire and 4, 5, 6 the chambers from which the counting gas is introduced. On the slotted side of the flow counter there is situated a cover plate 7 with a plate aperture 8. The cover plate 7 consists of a metal plate. At a slight distance from the counter tube cover plate 7 there is a conductive or non-conductive mounting material 9 which should make as good galvanic contact as possible with the conductive support-electrode 10 arranged below it. The radioactive source 11 is situated on the mounting-material 9. The voltage U_s for producing the additional field is applied to the terminals 12 and 13. The parts 7 and 10 form an electrical diaphragm system of the simplest kind.

If for reasons of space or because the insulation resistances of the mounting-material 9 are too high the radio-active source cannot be measured with the arrangement shown in Fig. 1, a system of electrical diaphragms according to Figs. 2 and 3 or Figs 4 and 5 is used instead of the diaphragm system 7/10.

The electrical diaphragm system of Figs. 2 and 3 consists of two conductive plates 14 and 15 between which an electrically insulating layer 16 is situated. The diaphragm system is provided with a narrow rectangular slot 17. A voltage U is applied to the contacts 18 and 19 to produce the additional field.

The electrical diaphragm system of Figs. 4 and 5 consists of a conductive plate 20

which has an aperture 21 in the form of a narrow rectangular slot and is generally directed towards the flow counter. An electrically insulating layer or plate 22 is arranged on the conductive plate 20. On this plate 22 are arranged two bars 23 and 24 with terminals 25 and 26 respectively to which a voltage U can be applied. Wires 27 and 28 are arranged in staggered formation like intermeshing combs on the bars 23 and 24. The individual wires 27 of the bar 24 are electrically insulated against the individual wires 28 of the bar 23. The wires 27 and 28 cover the slot-shaped aperture 21 like a grid. The voltage U is transmitted through the bars 23 and 24 to the wires 27 and 28 and produces the additional electric field between them.

The effect of increasing the counting efficiency by applying a negative voltage to the conductive support when measuring a non-conductive sample, is demonstrated in Fig. 6 in which Δ is the distance between the surface of the preparation and the flow counter shutter. The rate of counting for five sources of different activities is entered on the ordinate, the voltage U_s between 10 and 12 is entered on the abscissa. It will be seen that the counting rate is relatively low at positive voltages, then rises, as a voltage U_s drops to about O V, but reaches its maximum only at negative values of U_s. The counting yield could be increased up to a factor of about 2 compared with the value obtained for U_s=O V, the actual value depending on the charging conditions of the non-conductive source. At higher negative values of U_s, the resulting surface potential also becomes negative with respect to the flow counter cover plate; this finally leads again to a drop in the counting rate.

WHAT WE CLAIM IS:—

1. A flow counter for measuring radioactive materials, comprising a counter chamber which includes a counting wire at a positive potential with respect to the chamber and the entrance to which is covered with a cover plate containing an aperture, which is not foil covered, for admitting radiation, in which there is provided, in the immediate vicinity of the aperture an electrical diaphragm system producing an additional electrical field, the diaphragm being so positioned that the cover plate aperture lies in the region of the additional field.

2. A counter as claimed in claim 1, in which the diaphragm system is so arranged that the additional field has a component which is perpendicular to the plane of the cover plate in the aperture of the cover plate.

3. A counter as claimed in claim 2 in which the diaphragm system consists of two conductive plates arranged above one another and having a common aperture and which are separated from each other by an electrically insulating intermediate layer which has a similarly disposed aperture.

4. A counter as claimed in claim 2 in which the additional field is produced between a conductive cover plate, which is provided with the radiation inlet aperture, and a conductive electrode which serves as a support for the mounting-material carrying the radioactive source, so that the radioactive source is situated between the radiation inlet aperture and the conductive electrode.

5. A counter as claimed in claim 4 in which the direct voltage applied to the conductive electrode is positive with respect to the counter tube cover plate.

6. A counter as claimed in claim 4, characterised in that the direct voltage applied to the conductive electrode is negative with respect to the conductive counter tube cover plate.

7. A counter as claimed in claim 1 in which the additional field has a vector component which lies parallel to the plane of the cover plate in the aperture of the cover plate.

8. A counter as claimed in claim 7 in which the electrical diaphragm system consists of a conductive plate provided with an aperture and an electrically insulating layer also provided with a slotted aperture, which layer is arranged on the said plate and on which layer two intermeshing wire combs are arranged which are electrically insulated from one another and cover the aperture in the manner of a grid.

9. A counter as claimed in any of claims 1 to 8 in which the additional field contains in addition to a direct voltage component, an alternating voltage component, that is, the additional field is periodically varied in intensity.

10. A flow counter substantially as herein described with reference to Figures 1 to 5 of the accompanying drawings.

ELKINGTON AND FIFE,
Chartered Patent Agents,
High Holborn House,
52-54 High Holborn,
London, W.C.1.
Agents for the Applicants.

Berwick-upon-Tweed: Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd.—1967
Published at the Patent Office. 25 Southampton Buildings, London, W.C.2 from which copies may be obtained.

 COMPLETE SPECIFICATION

This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

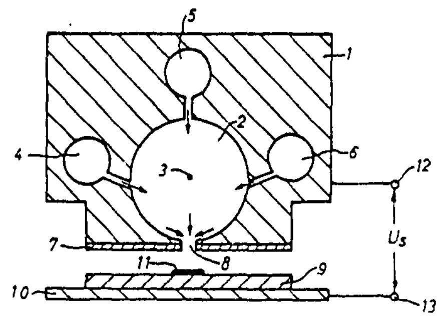

FIG. 1

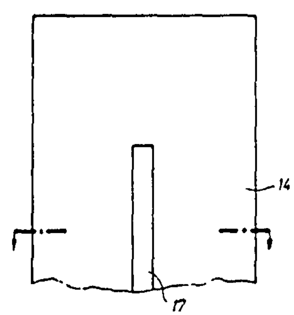

FIG. 2

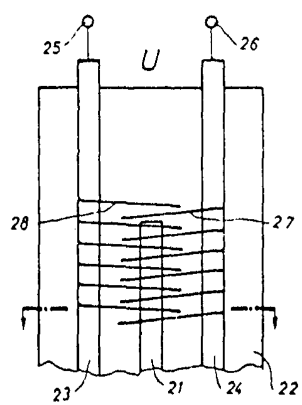

FIG. 4

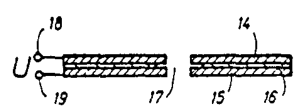

FIG. 3

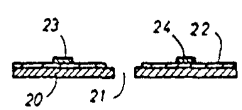

FIG. 5

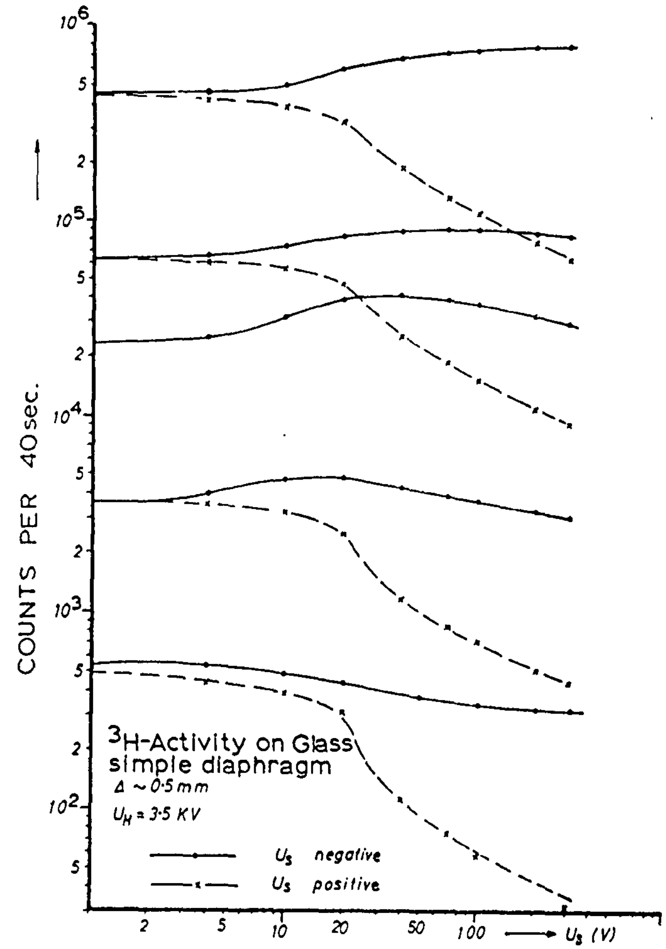

FIG. 6